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UDC 621.397.132:
621.397.61

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RESEARCH DEPARTMENT

1969
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REPORT

The number of picture-sampling points required for automatic colour-camera registration

No. 1969/25

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

RESEARCH DEPARTMENT

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It uses SI units in accordance with B.S. document PD 5686.

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(PH-39)

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SUMMARY

It has been proposed that an automatic colour-camera registration system should be developed for use within the BBC. The correction system will sample selected areas of picture information and, from these samples, will generate correction waveforms which will be applied to the camera in order to offset the registration errors.

The purpose of this investigation was to ascertain the bandwidths necessary for the correction signals, as these will determine the number of samples of picture information required. The results obtained indicate that the minimum number of samples required to reconstitute the correction waveforms would be thirty-five, in a rectangular array of seven samples horizontally by five samples vertically.

1. INTRODUCTION

A colour-camera contains at least three tubes, and for automatic registration-correction purposes[1] one of these represents a reference (the 'master tube') and the others are 'slave tubes'. The scanning systems associated with the two slave tubes, or their video output signals, are separately subjected to individual corrections in order, effectively, to bring their picture images into registration with that of the 'master'. Fig. 1 gives an exaggerated illustration of the registration errors that might exist between the master tube and one slave tube when viewing a grille pattern. The waveforms effecting correction in the horizontal and vertical axes will both contain components at the line and field frequencies, and their harmonics.

The registration correction system employs sampling of the tube outputs in both the line (horizontal) and field (vertical) directions, and the registration errors of a slave tube which occur at a point on the original picture can be specified in terms of timing errors between corresponding samples from the master tube and the slave tube.

The correction system introduces into each slave-tube scanning system or output signal, vertical and horizontal timing corrections such as to restore coincidence between corresponding samples from the master tube and each of the slave tubes, and the bandwidths required for the horizontal and vertical correcting signals are directly related to the rates of change, with time, of the magnitudes of the registration errors in these directions.

The main purpose of the investigations to be described was to determine the bandwidths of the correction signals which would be required in a practical registration-correction system, and hence to determine the minimum rates of horizontal and vertical sampling which would provide these corrections.

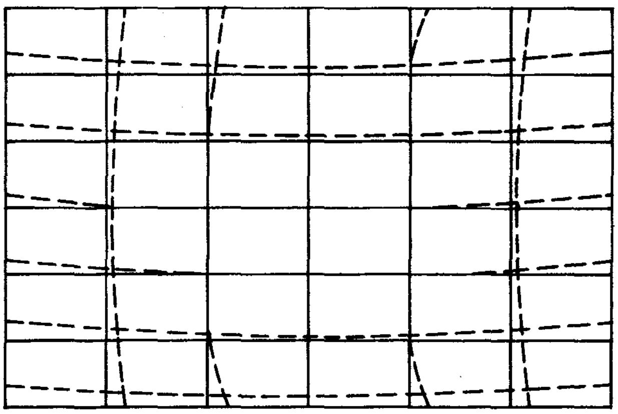

Fig. 1 - Registration errors between the master tube and one slave tube

2. EXPERIMENTAL DETAILS

The investigations were carried out using a camera channel whose registration errors were considered to be representative of those obtained in the three-tube and four-tube cameras used in service.

The picture used for the measurements was a colour-camera registration-chart which was arranged to occupy the whole of the picture area. Best possible registration between the tubes was obtained by standard operational procedures using the green tube as the master. As the investigation had to be concerned with the 'worst-case' and, as the greatest residual registration errors were observed

to be between the green tube and the luminance tube, the results of this work are based on the errors existing between this pair of tubes.

The registration errors were measured at 121 points over the whole picture area, corresponding to divisions of both the horizontal and vertical picture dimensions into eleven equal parts, as indicated in Fig. 2. The errors were measured at the centre of each elementary area by using a switched video delay in series with the output from the luminance channel. At each point the horizontal registration error was determined directly in nanoseconds, and a close estimate of the vertical error (in equivalent nanoseconds) was made by comparing the vertical displacement of the grille pattern, required to effect registration, with an identical shift in the line direction. These values enable the sampling rate required in the line direction to be calculated.

The results were transformed into equivalent timing errors in the field direction; these in turn enabled the sampling rate in the field direction to be derived.

The accuracy of the measurements was estimated to be ±15 ns in the line direction, and equivalent to ±7 μs in the field direction.

In order to determine the sampling rates required in the line direction, it must be remembered that the horizontal and vertical registration errors are to be corrected simultaneously as the tube scanning process takes place. Take for example row A of Fig. 2. As the line scan proceeds, both horizontal and vertical corrections are applied to the slave tube in question for the intervals corresponding to say area A1, followed by two more signals for area A2, and so on, to the end of a line. The process is then repeated for each elementary area of the whole picture. Consequently, a series of horizontal and vertical error curves were plotted for each of the rows A, B, C, ... K; the vertical errors in these instances were expressed in equivalent nanoseconds which were derived by the method described above.

Further, columns 1 to 11 are each scanned in a time interval equal to the active field period, and both horizontal and vertical correction signals are required for every area A to K in each column. The measured horizontal and vertical registration errors for columns 1 to 11 were plotted as another series of curves with the timing errors expressed in terms of the active field period.

3. RESULTS

Examples of the curves are given in Fig. 3 to Fig. 9. A deliberate attempt was made in drawing these curves to avoid sharp transitions in the time functions, other than those imposed by the limits of experimental error indicated on the figures. The information provided by these curves can therefore be used to determine the minimum bandwidths for the correction signals which would be effective in counteracting the registration errors. The experimental errors illustrated in Fig. 3 to Fig. 9 represent a change in misregistration which is hardly discernible when judged on a subjective basis. Thus, in principle, the performance of an automatic registration system based upon the results obtained should be high.

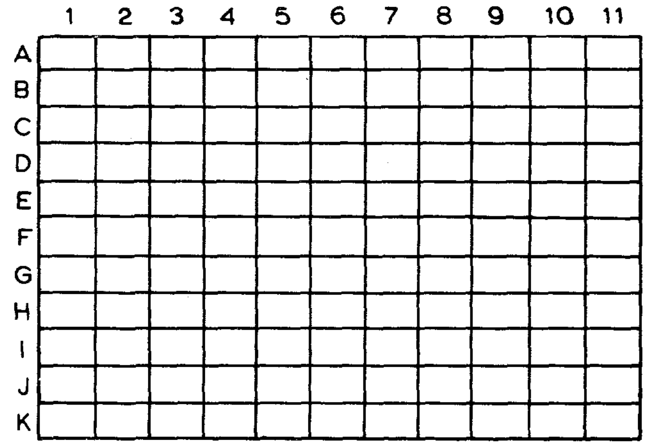

Fig. 2 - Division of picture area for measurement of registration errors

The bandwidths of the correction signals were ascertained by evaluating the rise-times of the sharpest transitions in the time functions and substituting these figures in the following formula:

$$f = \frac{1}{2t} \qquad (1)$$

where

t = time taken for a pulse to rise from 10% to 90% of its final amplitude
f = bandwidth

This procedure was applied to the curves expressing horizontal and vertical errors in terms of the active-line duration, and the maximum bandwidth recorded was 65 kHz. The same technique applied to the errors expressed in terms of the active field duration yielded a maximum bandwidth of 116 Hz.

The results of the investigation may be expressed as follows:

Minimum sampling frequency in the line direction:	130 kHz
Minimum number of samples per active line:	≃7
Minimum sampling frequency in the field direction:	232 Hz
Minimum number of samples per active field:	≃5

4. DISCUSSION OF RESULTS AND CONCLUSIONS

It will be noted from Fig. 3 to Fig. 9 that in many cases the shape of the correction waveforms could be reduced to that of a simple parabola; in a practical system the shape and amplitude of this parabola would have to be varied from line to line. Experiments have been carried out in simulating automatic correction using this technique

of parabolic correction at line frequency and the effects appeared to be quite promising with the yokes fitted in the camera used for the investigations. However, the individual characteristics of different types of camera yokes could preclude the general adoption of this method.

The results tend to show that a minimum number of 35 samples over the picture area should be quite satisfactory for an effective correction system.

During initial studies of the automatic registration system, it was suggested that the picture could be divided into 108 elementary areas distributed 12 x 9 in the horizontal and vertical directions respectively. This would involve correction-signal bandwidths of approximately 115 kHz in the line direction and 240 Hz in the field direction. The results of this investigation indicate a minimum picture subdivision of 7 x 5 with correction-signal bandwidths of 65 kHz and 116 Hz respectively and these easements may be useful in overcoming some practical problems which may arise as the overall system development proceeds.

5. REFERENCES

1. Means for automatically registering a colour camera. British Patent Number 38502/68.

2. The effect of registration errors in three-tube and four-tube colour television cameras. BBC Research Department Report No. PH-11, Serial No. 1967/47.

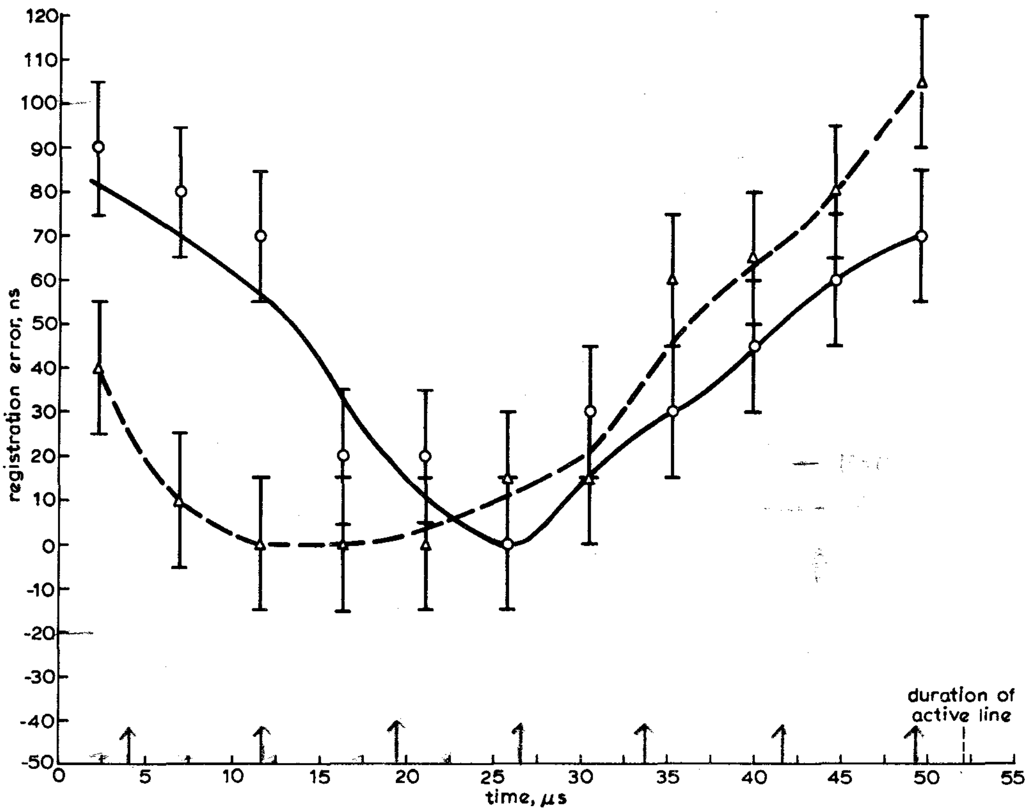

Fig. 3 - Horizontal and vertical registration errors for Row A

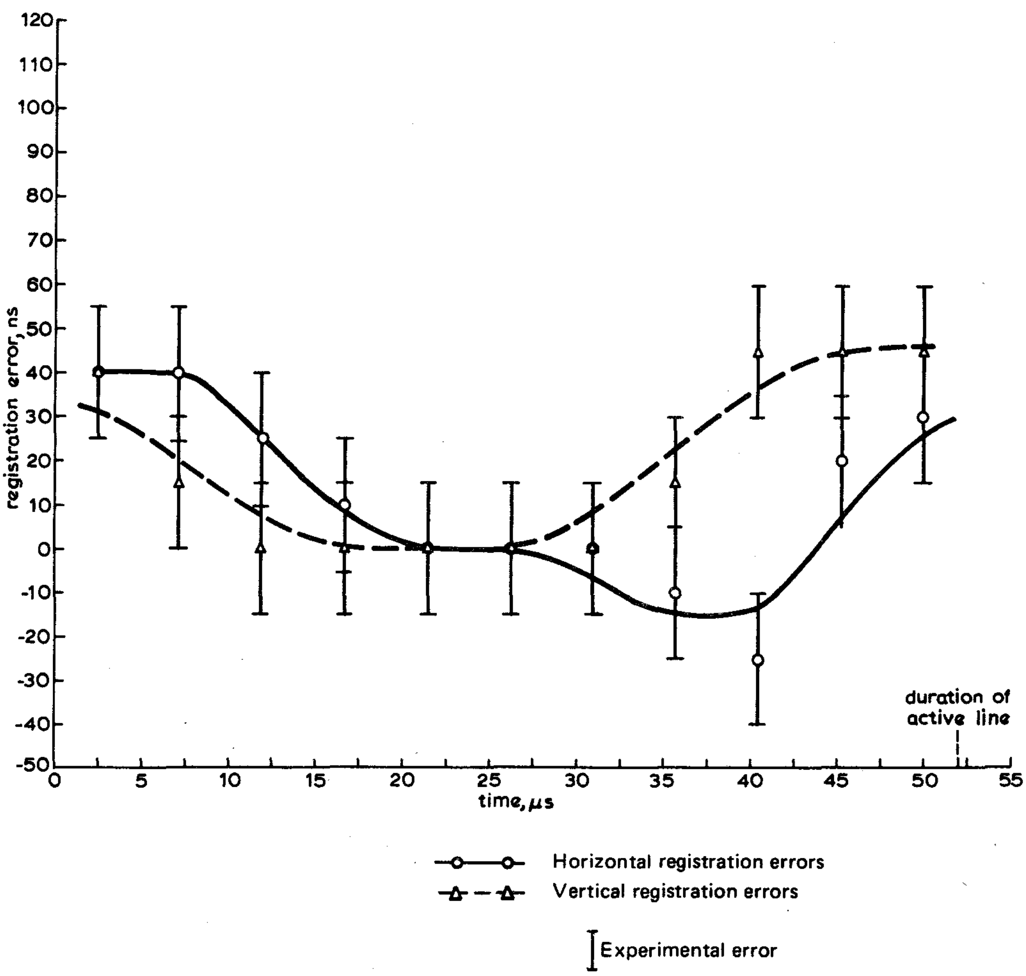

Fig. 4 - Horizontal and vertical registration errors for Row D

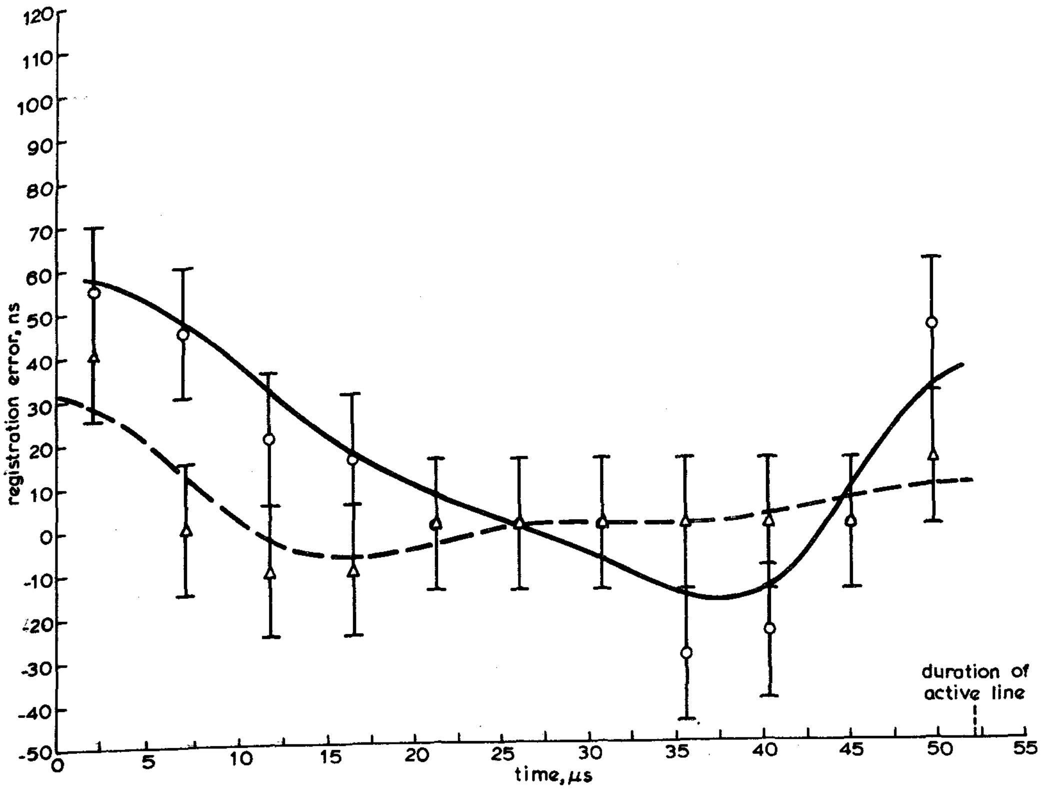

Fig. 5 - Horizontal and vertical registration errors for Row F

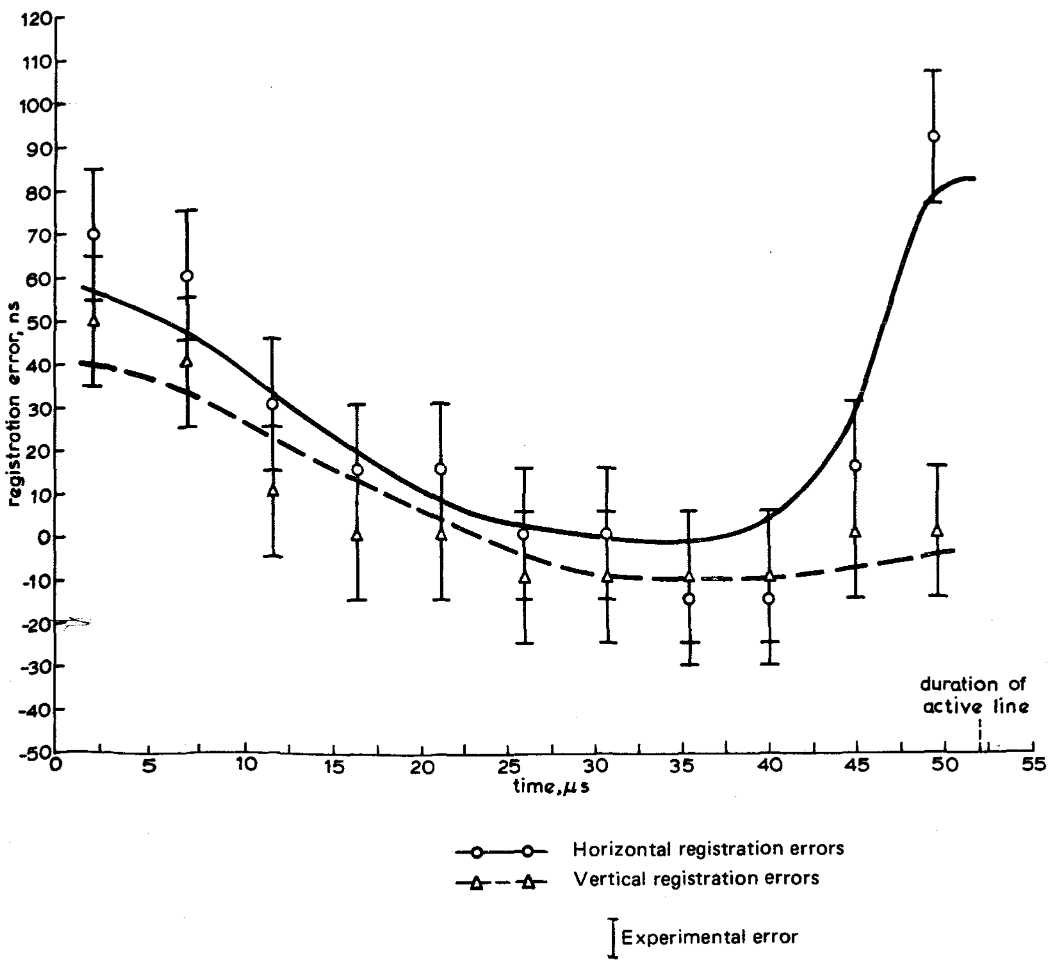

Fig. 6 - Horizontal and vertical registration errors for Row I

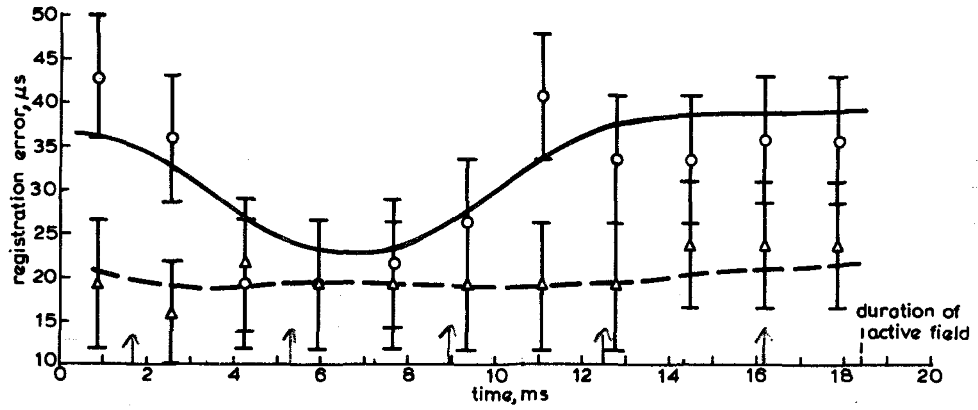

Fig. 7 - Horizontal and vertical registration errors for Column 1

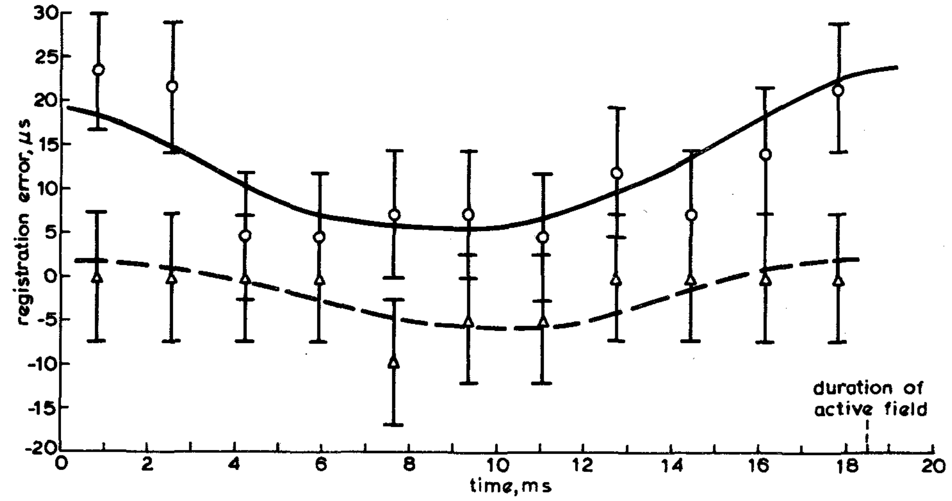

Fig. 8 - Horizontal and vertical registration errors for Column 4

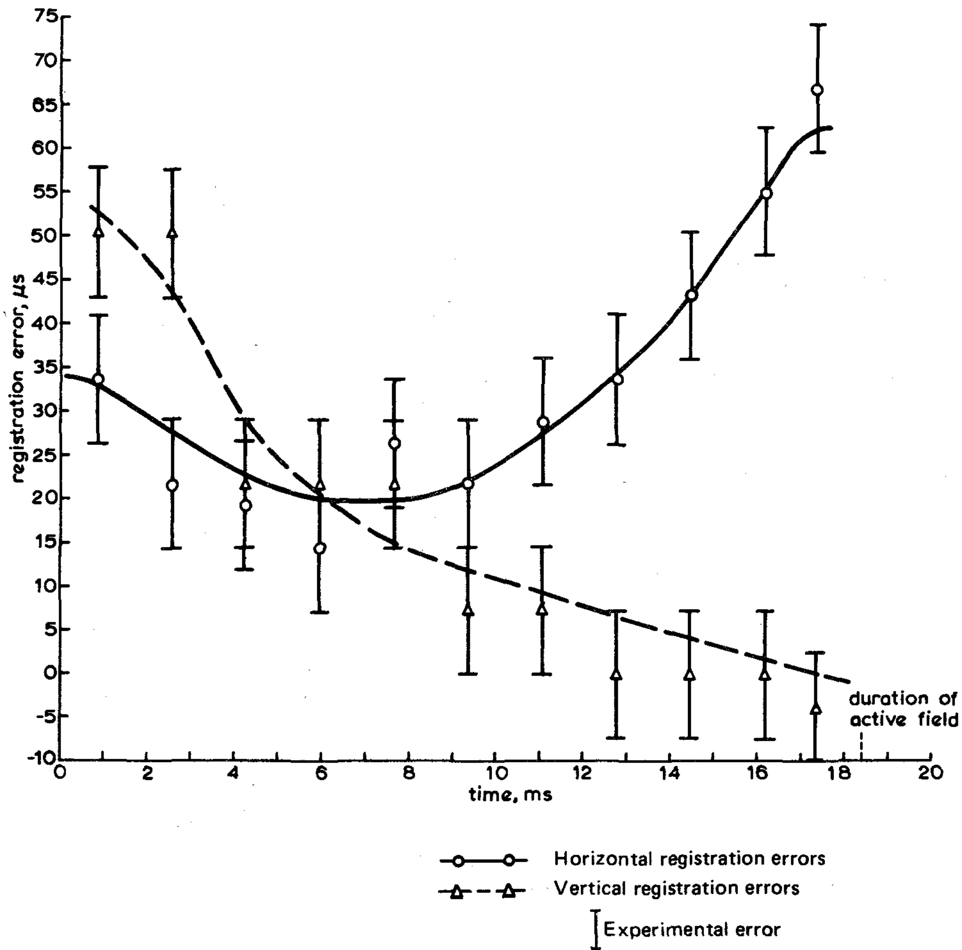

Fig. 9 - Horizontal and vertical registration errors for Column 11

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